



A Look at Intra-season to Inter-annual Variability in 12 years of AIRS Nadir-view Radiances and AIRS-CERES Spectral Fluxes

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Roadmap

- Motivation and Background Information
 - Archiving AIRS nadir-view radiance
 - Spectral fluxes estimated from the collocated AIRS and CERES observations
 - Spectral EOF (PCA) analysis
- Standard deviations of global-mean spectral radiances and fluxes
 - Comparison with published IASI results
- Spectral EOF analysis results (working in progress)
 - Global mean
 - Hemispheric mean
 - Zonal mean

What 12 years of AIRS data can tell us about spectral variability over different time scales?

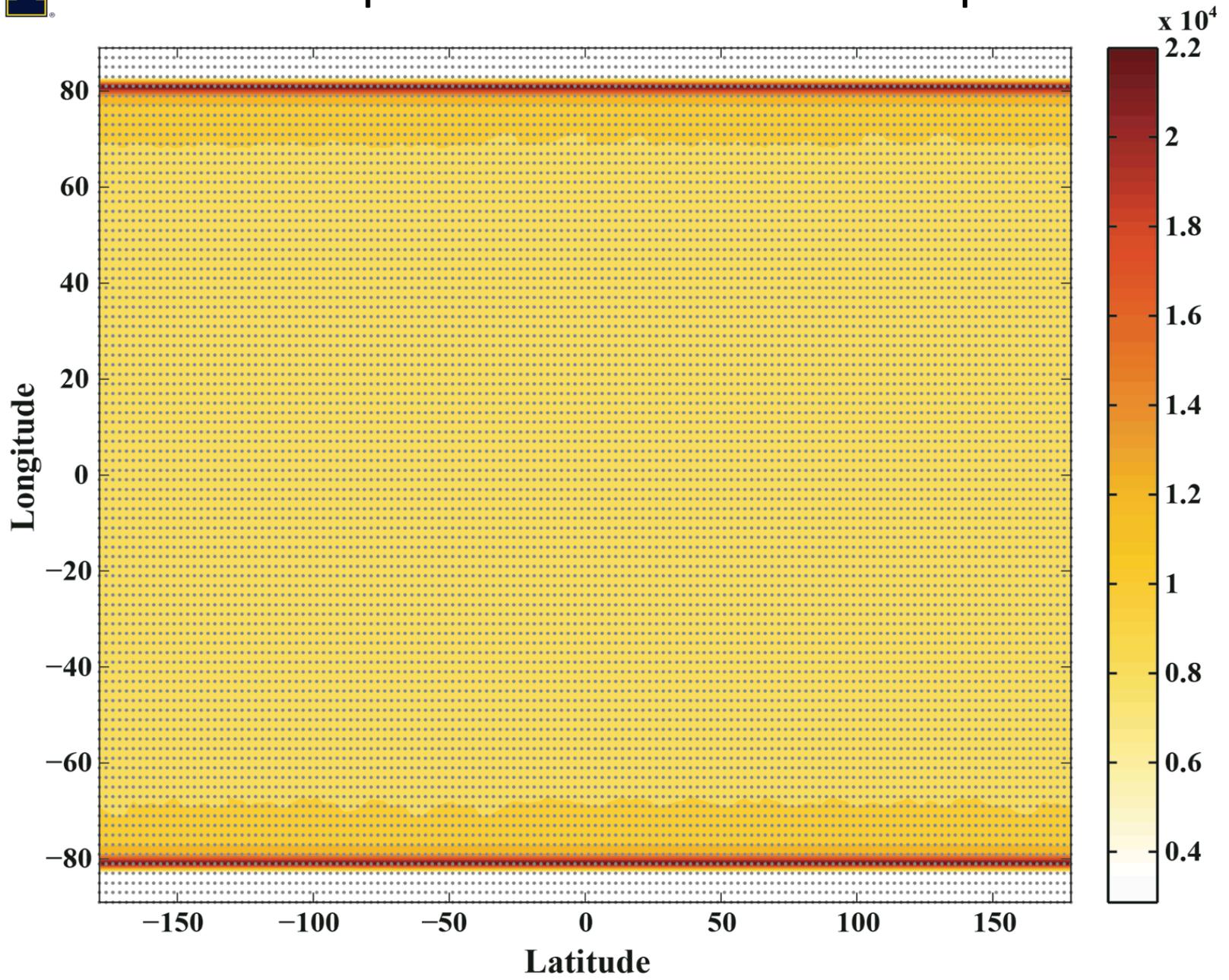


Motivation and Background Information

- AIRS radiances (Sep 2002 to present)
 - L1B nadir-view radiances archived in nearly real time
 - Follow Huang & Yung (2005, JGR) procedures
 - Quality control of each AIRS spectrum
 - Bad channel detections (2081 out of 2378 channels used)
 - Average onto 2.5 lat by 2.0 lon grids; 16-day average for the uniform samplings
 - Ascending and descending nodes are processed separately then are averaged with equal weight
 - Using detrended data up to Dec 2014 in this analysis



Number of qualified nadir-view AIRS spectra in 2004





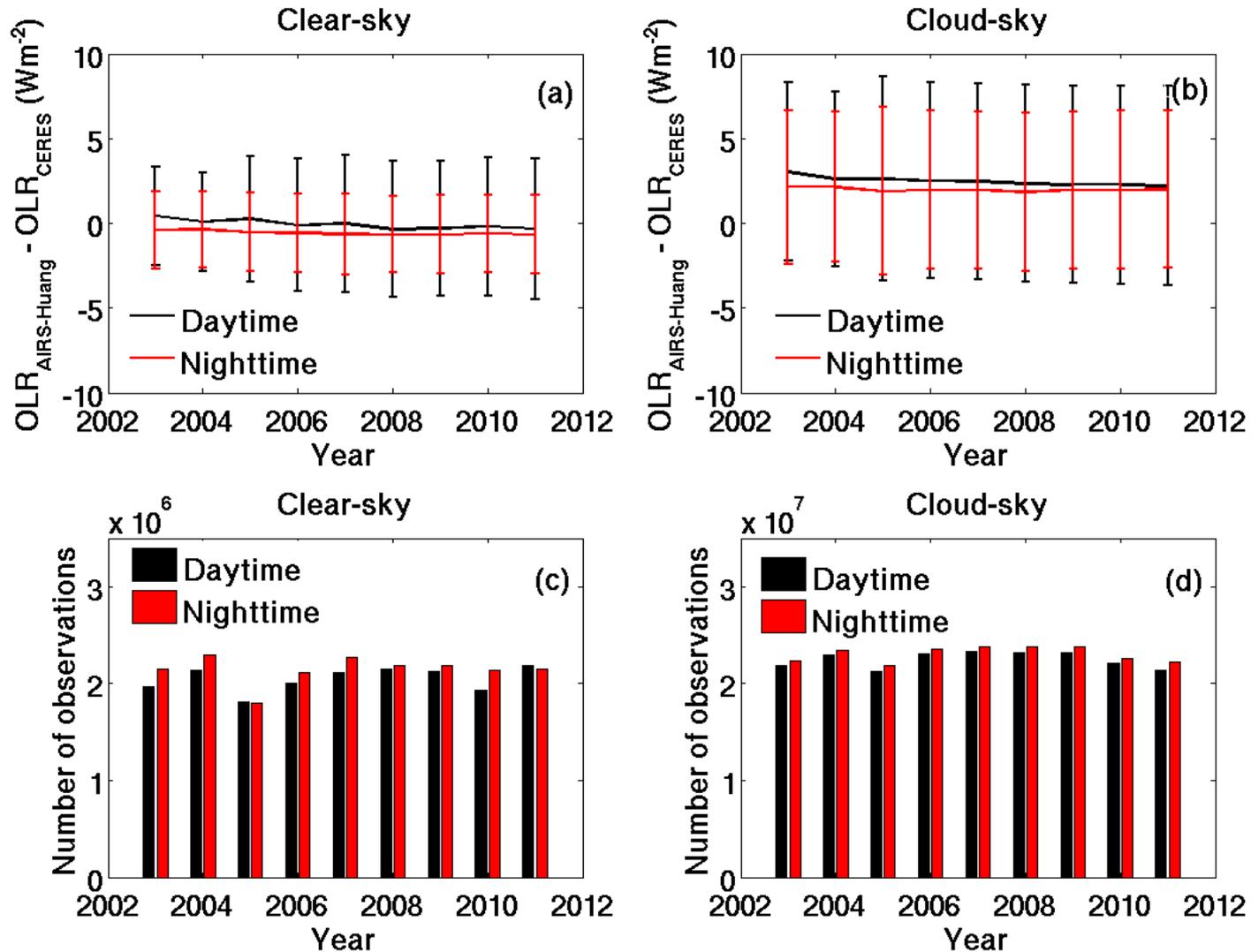
Motivation and Background Information

- The full LW spectral flux based on collocated AIRS and CERES observations
 - Leverage on the sophisticated scene type information from CERES SSF data set
 - Invert spectral flux using the pre-constructed spectral ADMs
 - Estimate spectral flux not covered by the AIRS instrument with a PCA-based regression scheme
 - Detrended spectral flux at 10 cm⁻¹ interval from 10 to 2000 cm⁻¹ (Sep 2002 to Nov 2014)

Ref: Huang et al. (2008; 2010; 2014), Chen et al. (2013)

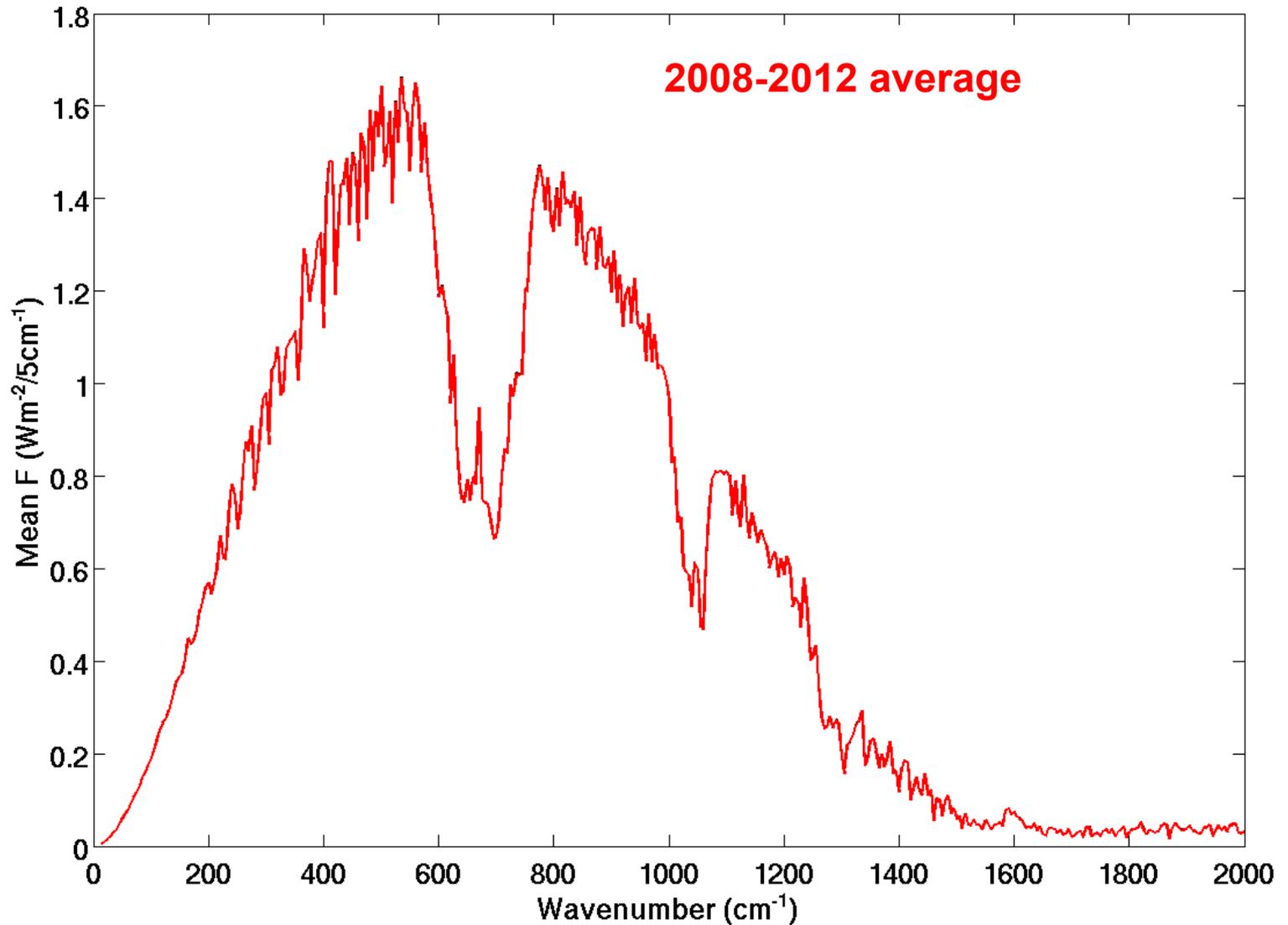


Global $OLR_{AIRS_Huang} - OLR_{CERES}$: annual means and year to year changes



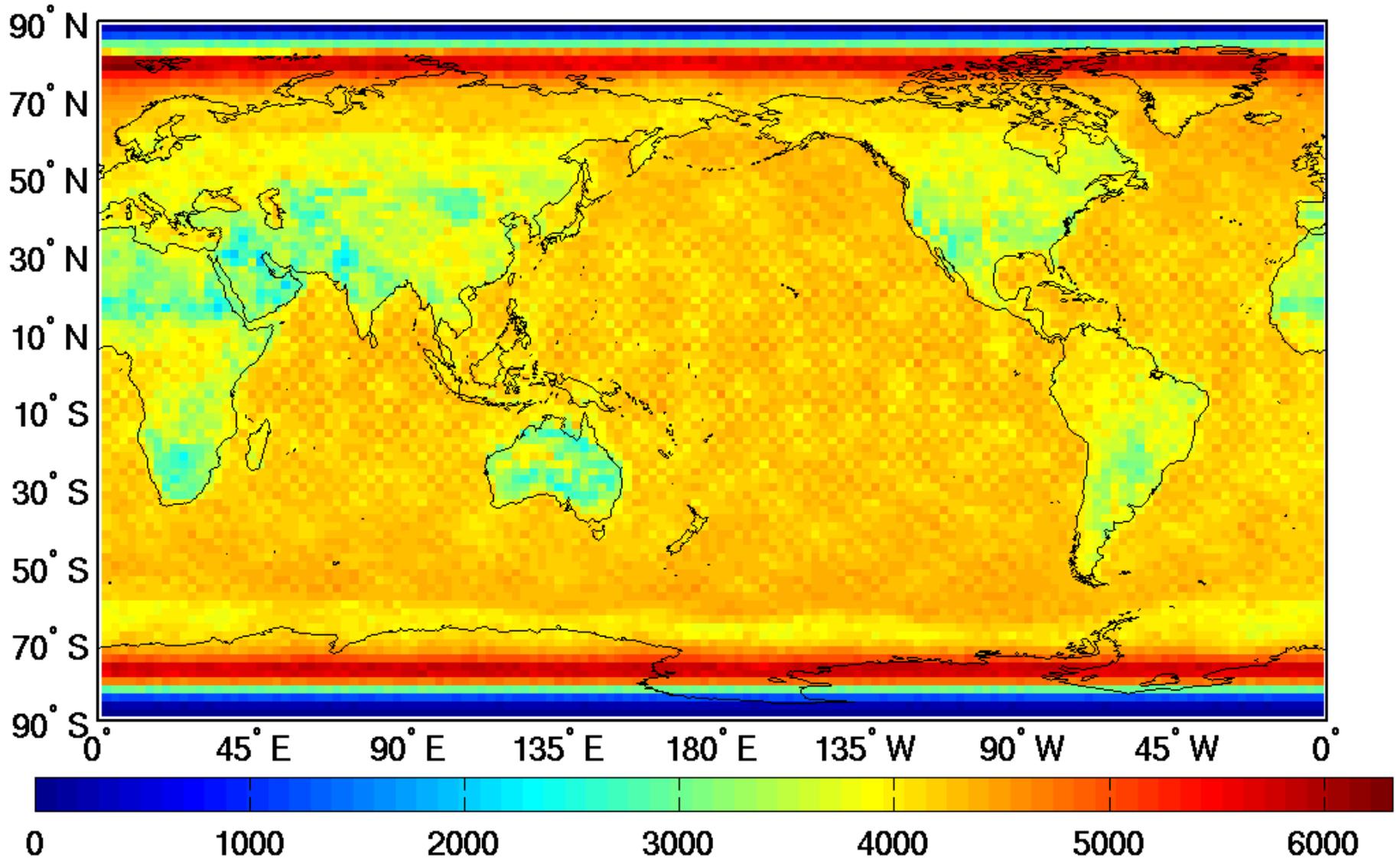


Global mean spectral flux with 10cm^{-1} spectral interval





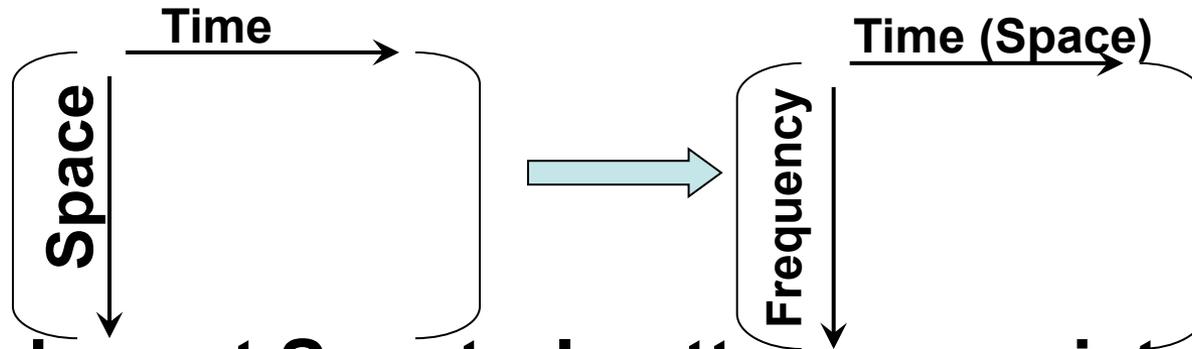
Number of collocated observations used in averages for 2004





Spectral EOF

- **Similar to the EOF approach widely used in climate data analysis**



- **Coherent Spectral patterns persistent from time to time (or from location to location)**

Observation anomaly $A = (I_1(\nu), I_2(\nu), \dots, I_n(\nu))$

$C = AA^T$, $C\phi_i = \lambda_i\phi_i$ where $\lambda_i \geq \lambda_{i+1}$

Principal Component $PC^{(i)} = \sqrt{\lambda_i}\phi_i$

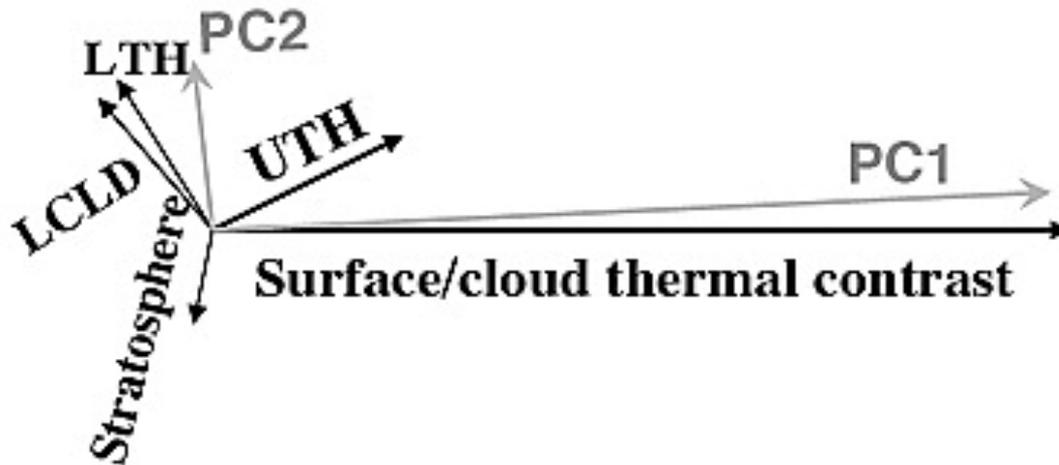
Normalized Expansion Coefficient (time series, or spatial pattern)

$$EC^{(i)}(t) = \left\langle \frac{PC^{(i)}}{\lambda_i}, A \right\rangle$$

**PC has the same dimension as radiance
EC is normalized (std = 1)**

Spectral EOF: the interpretation

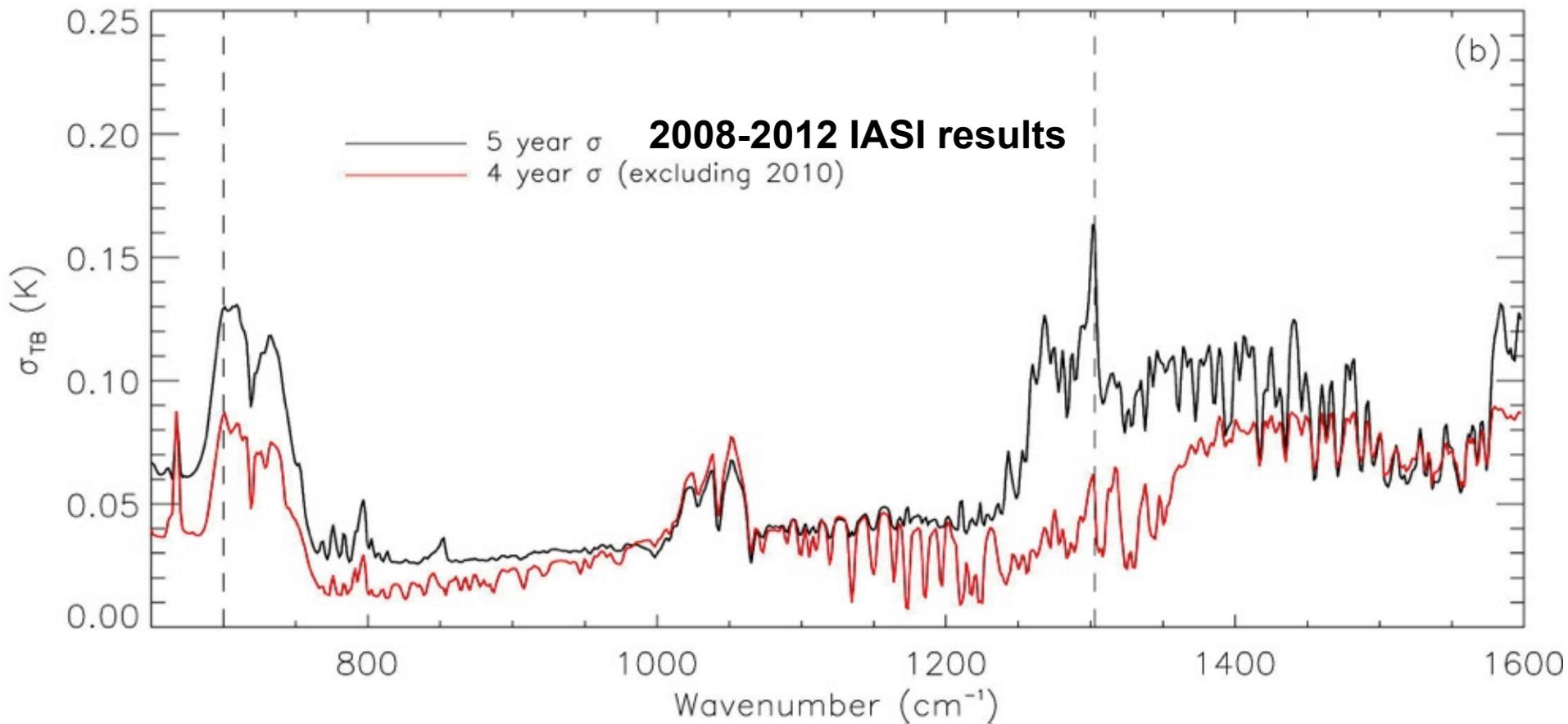
- Always start from the PC1
- Forced linear orthogonality can complicate the physical interpretation



(Huang & Yung, 2005)



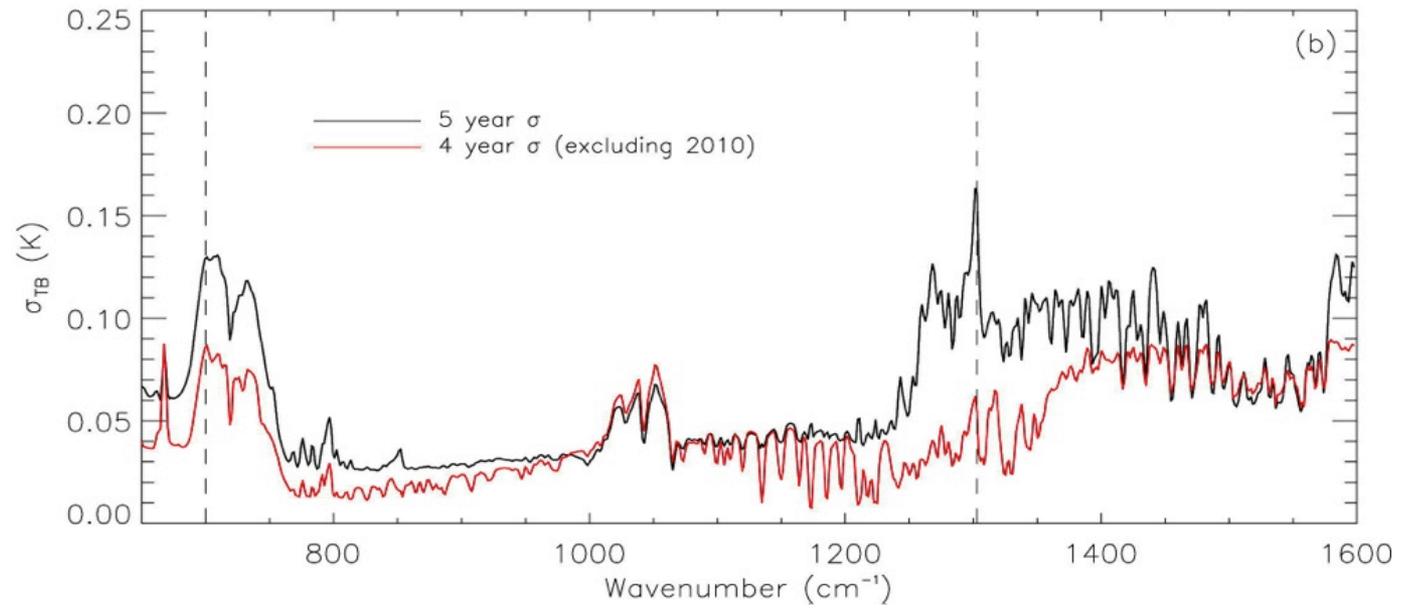
Standard deviations of annual global-mean spectra



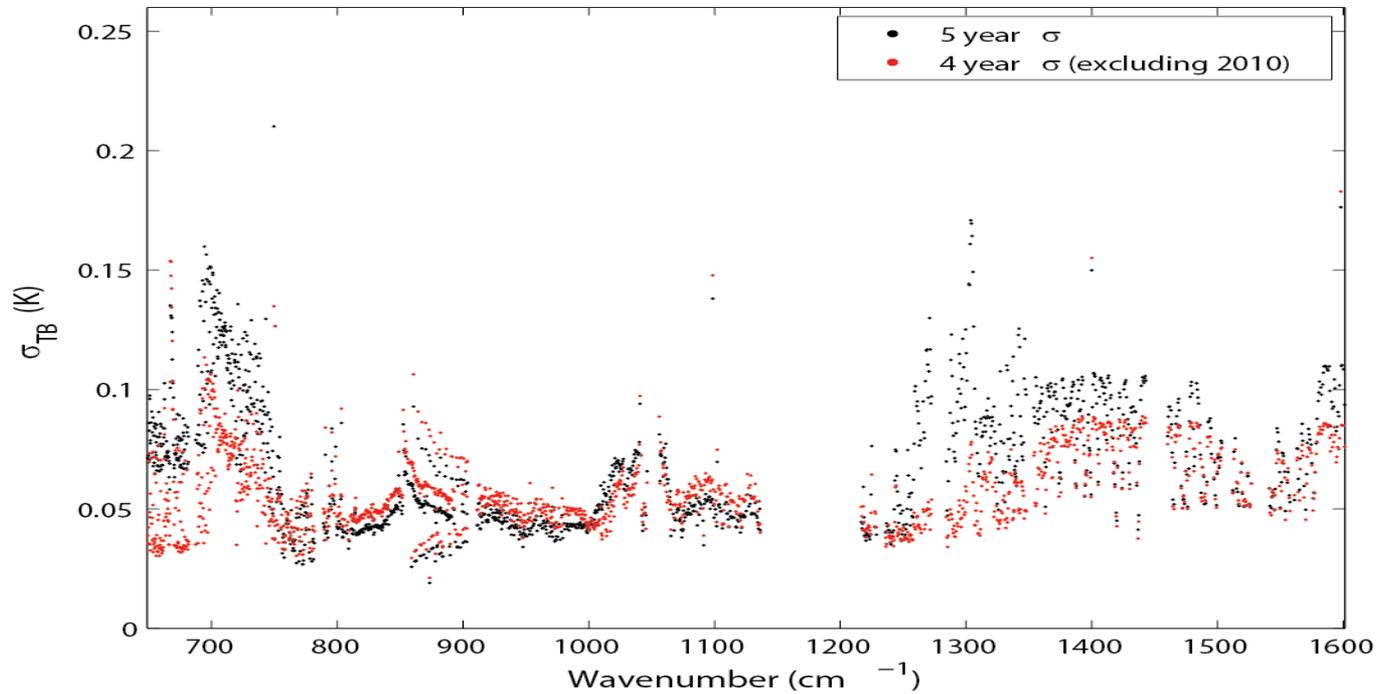
Brindley et al., J. Climate, 2015

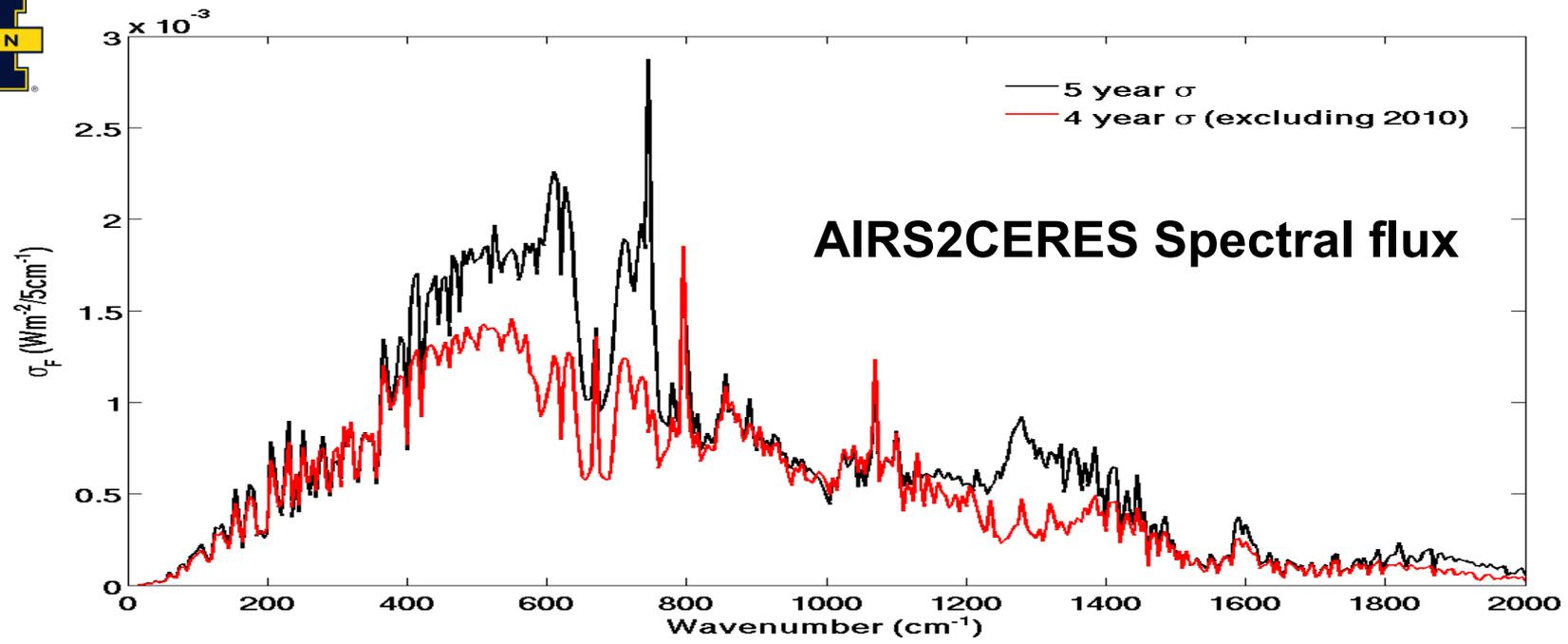


IASI

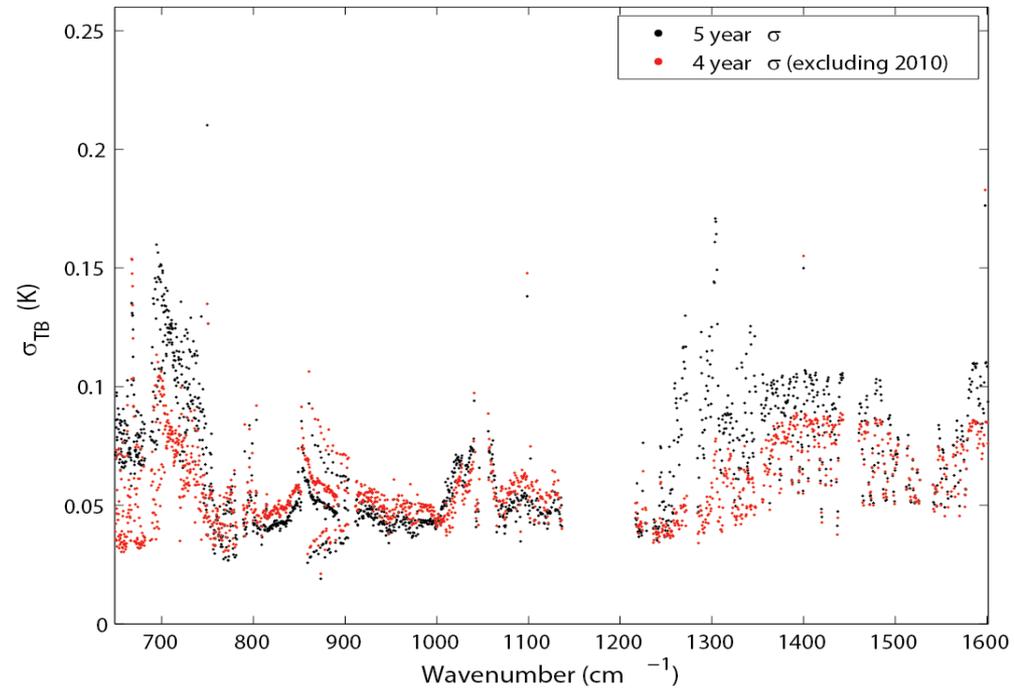


AIRS



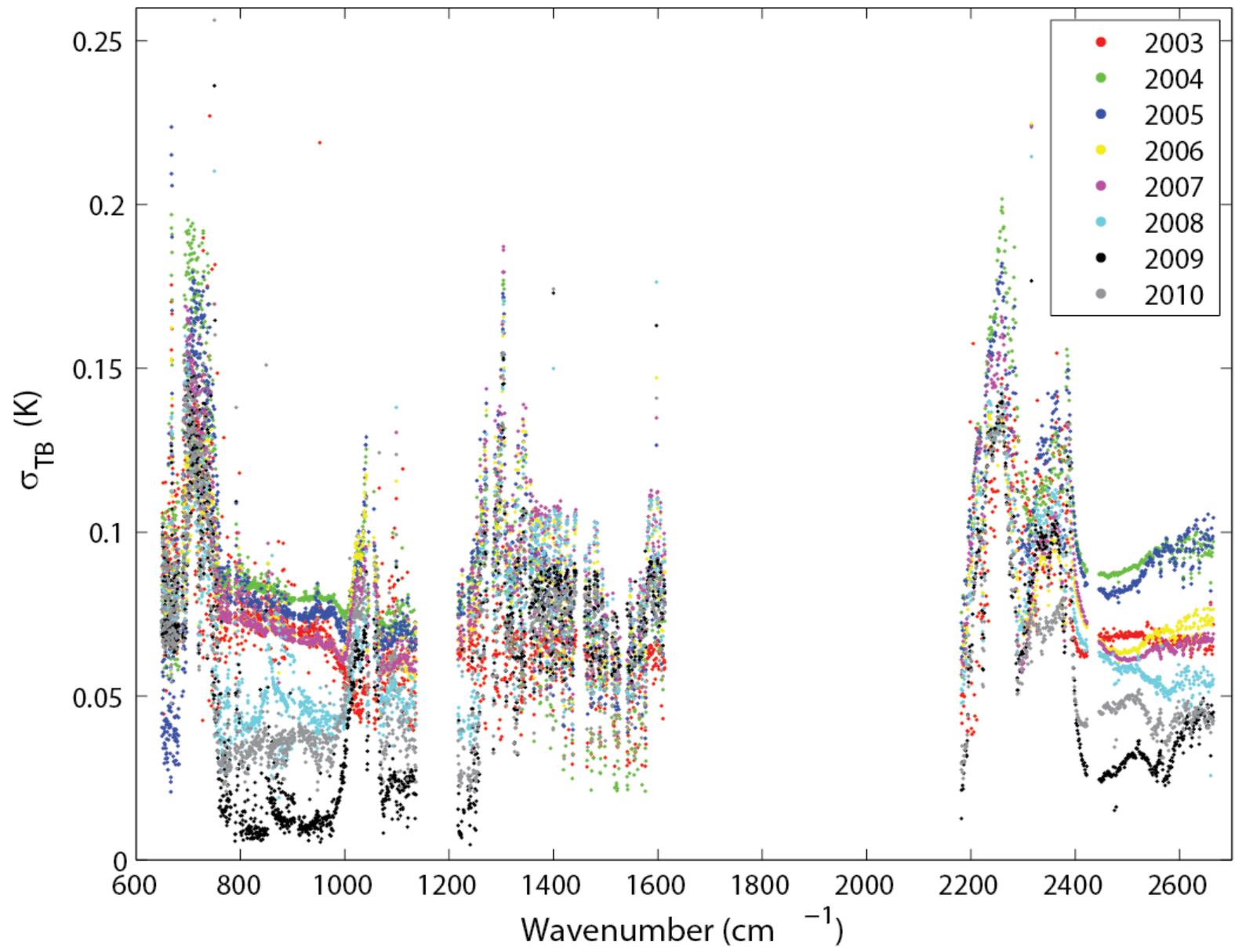


AIRS



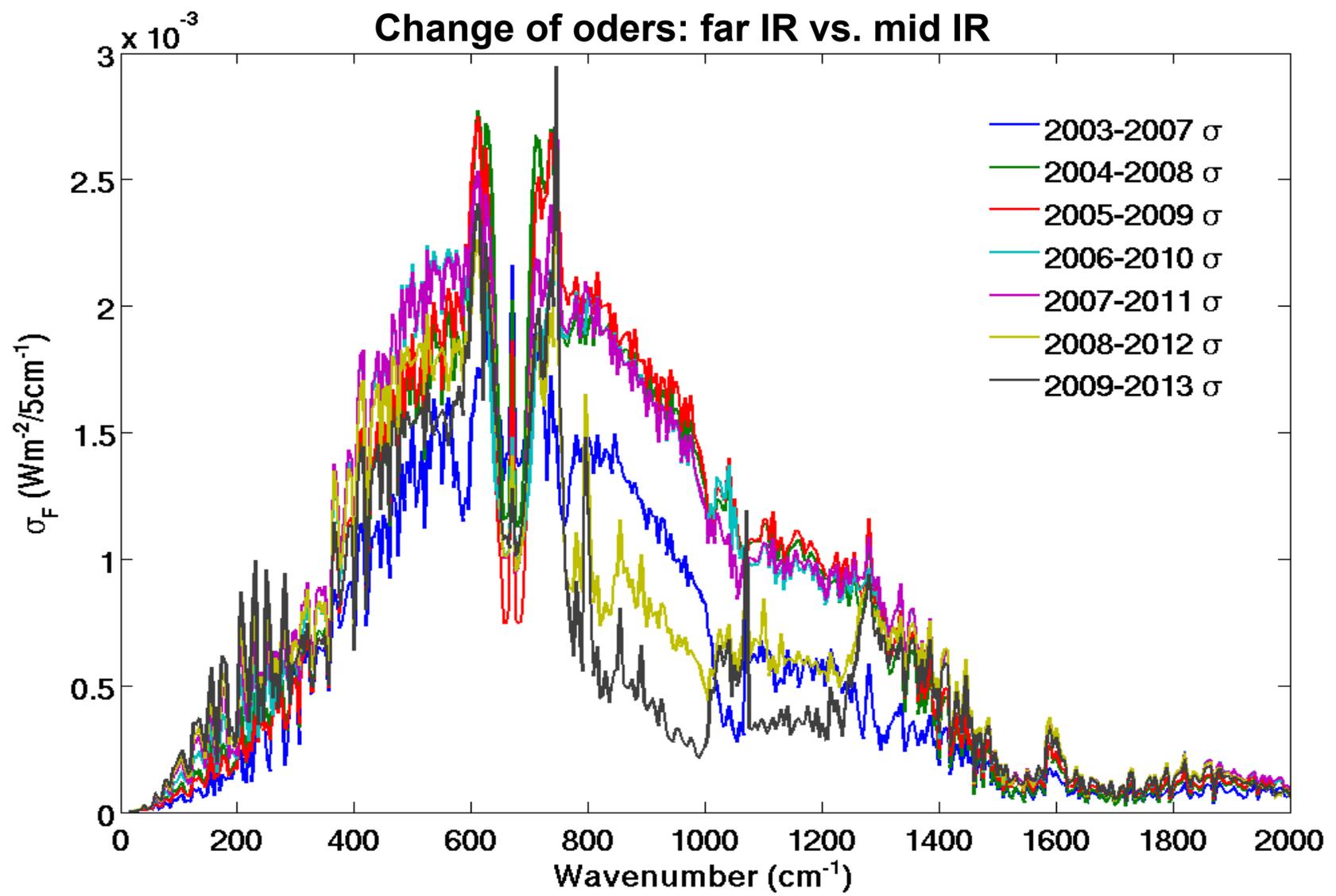


All 5-year segments: AIRS





All 5-year segments: Spectral flux

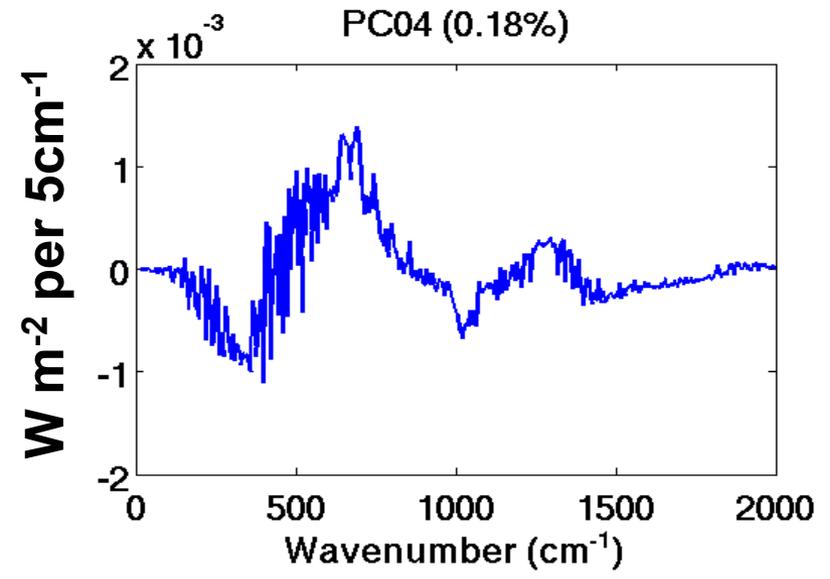
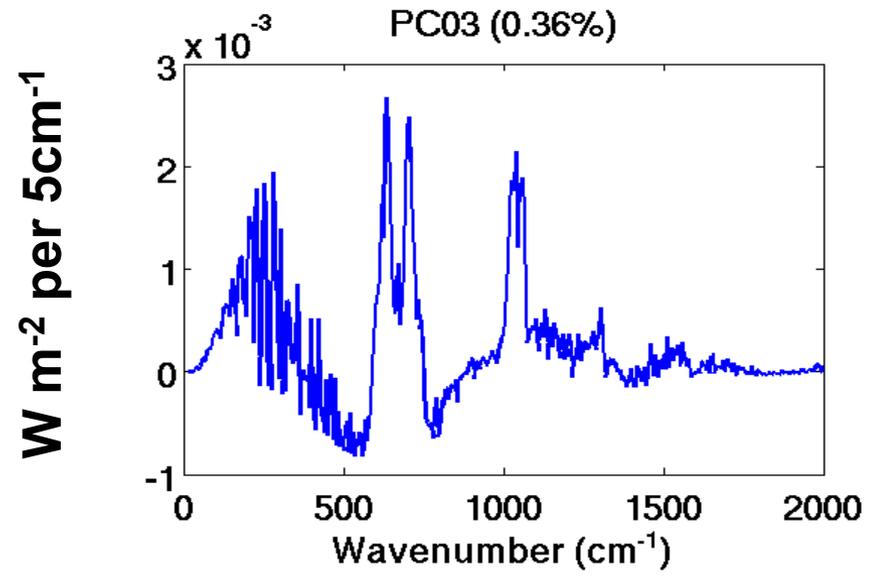
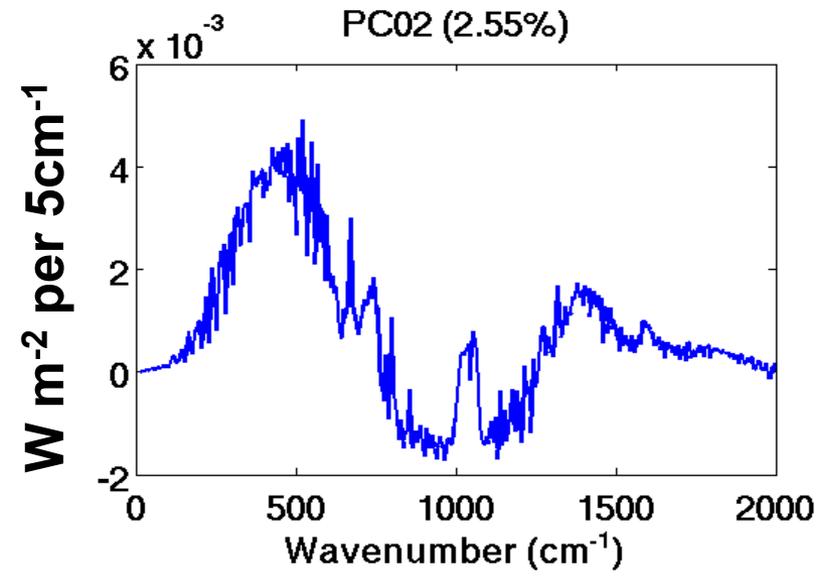
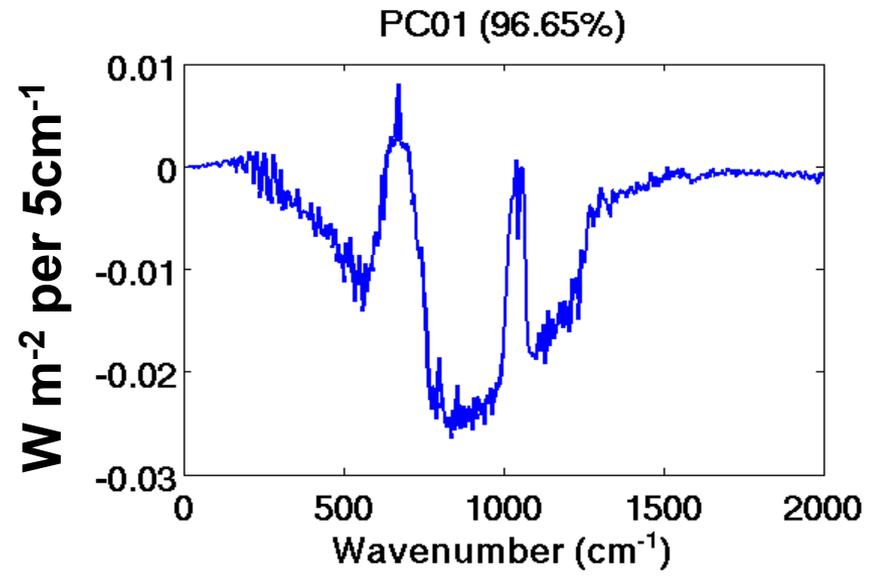




Spectral EOF analysis

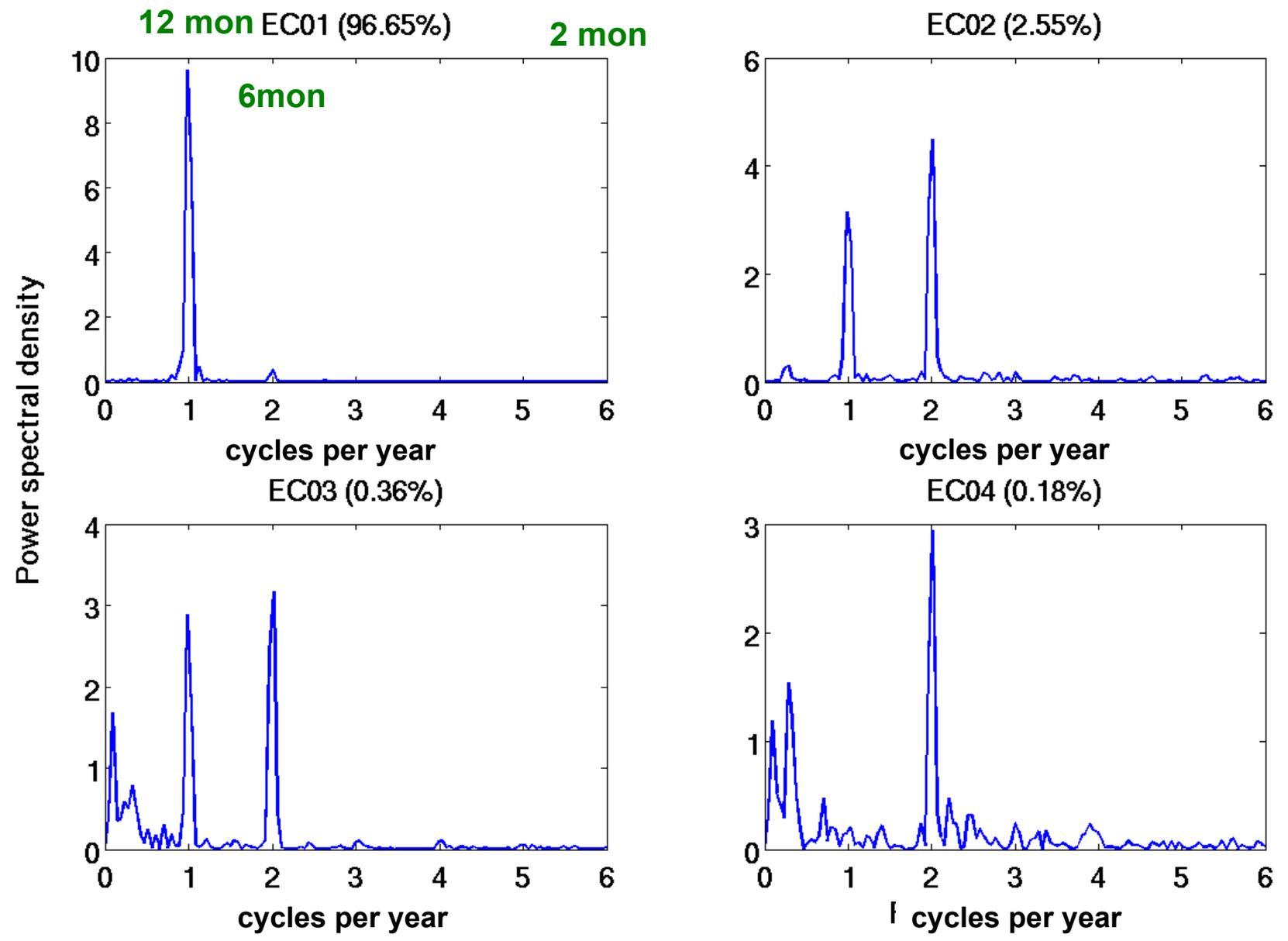


Global-mean spectral flux: PCs





Global-mean spectral flux: Power spectra of PC time series





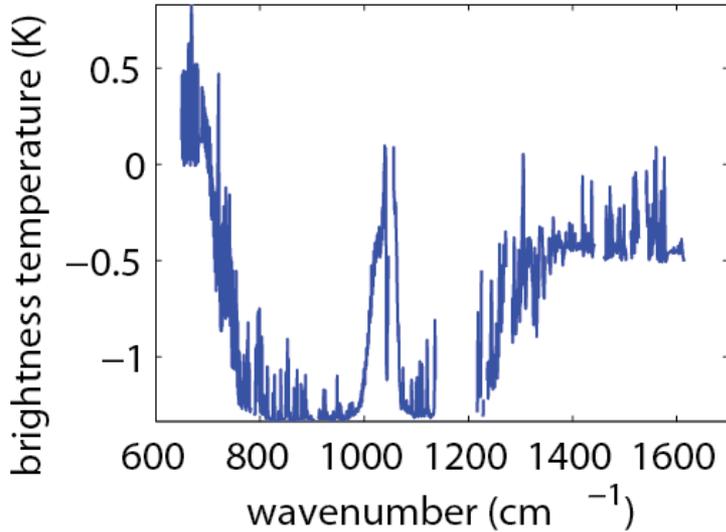
Why is seasonal cycle still so dominant?

- Thermal contrast: Many channels are sensitive to boundary emission (surface or thick cloud top), more than anything else.
- Seasonality in global-mean surface temperature
 - Land-sea contrast: NH vs. SH
 - Eccentricity

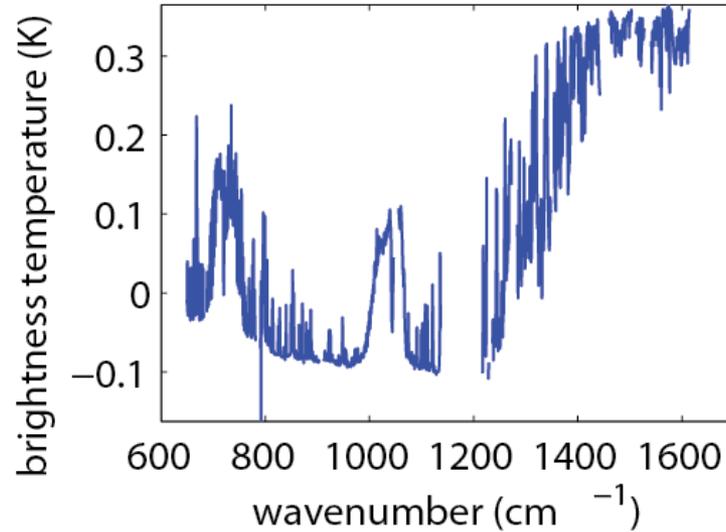


Global-mean AIRS nadir radiances: PCs

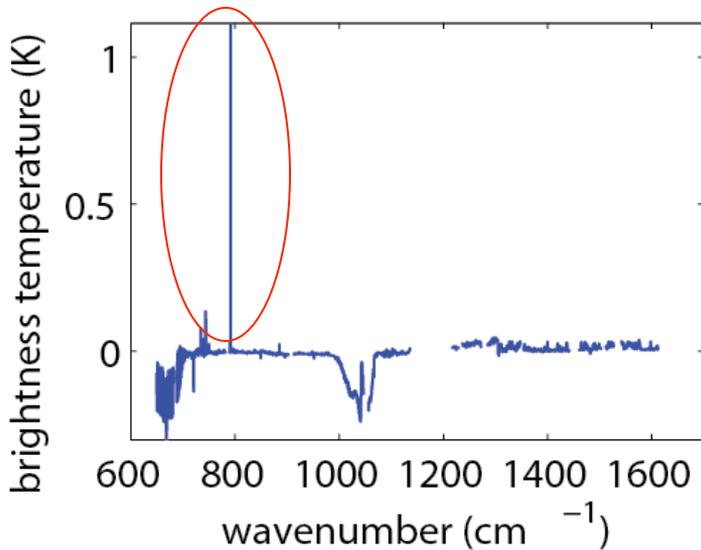
PC 1 0.947



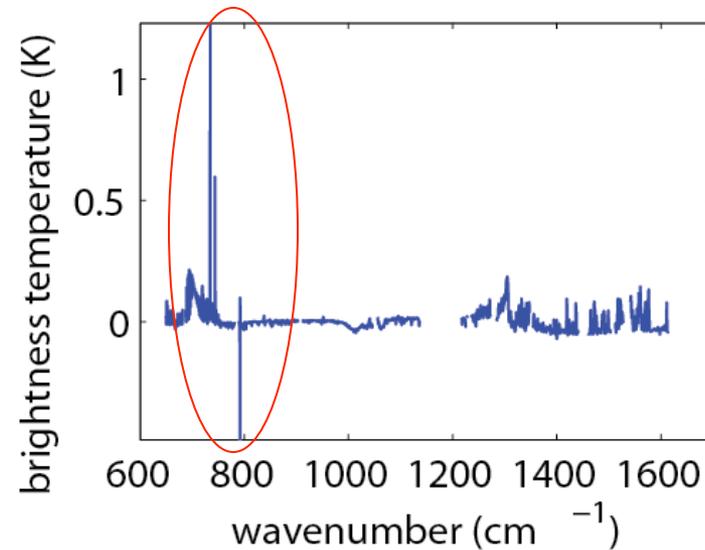
PC 2 0.031



PC 3 0.005

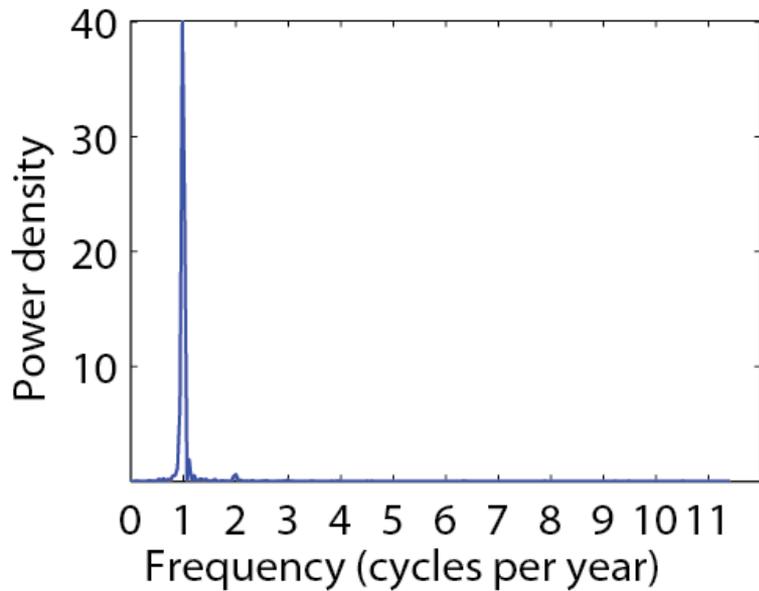


PC 4 0.004

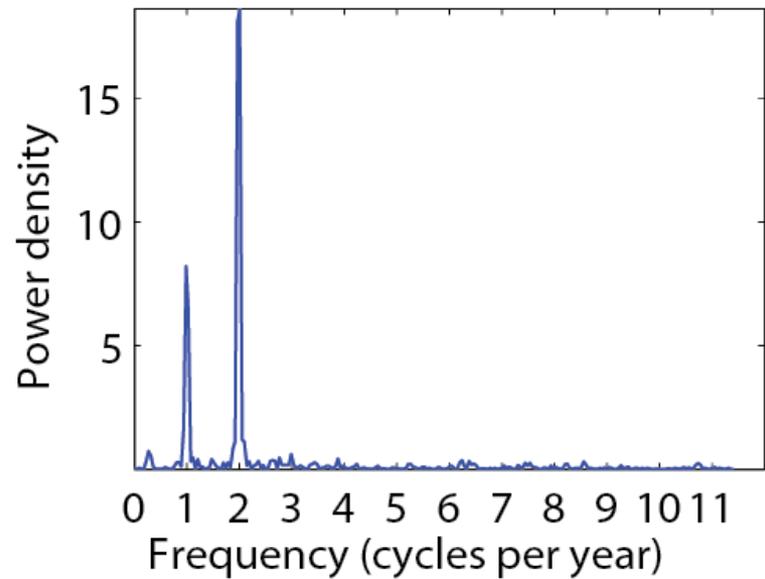




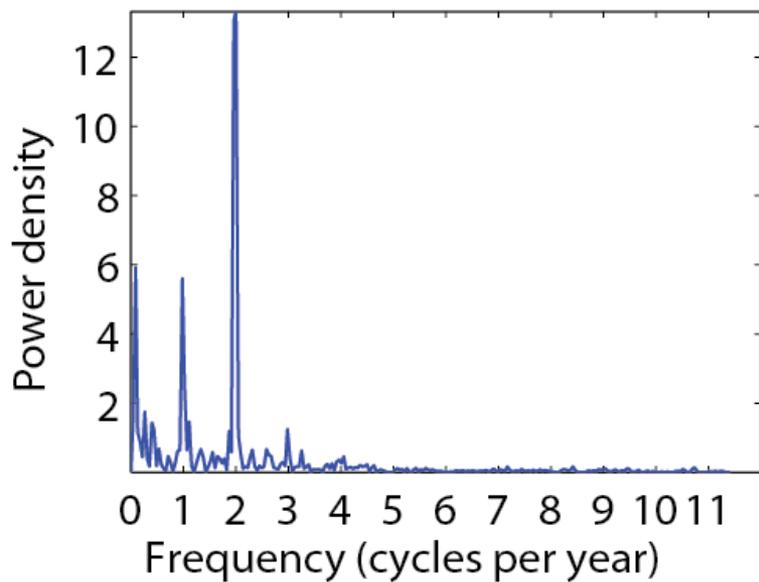
EC 1 0.947



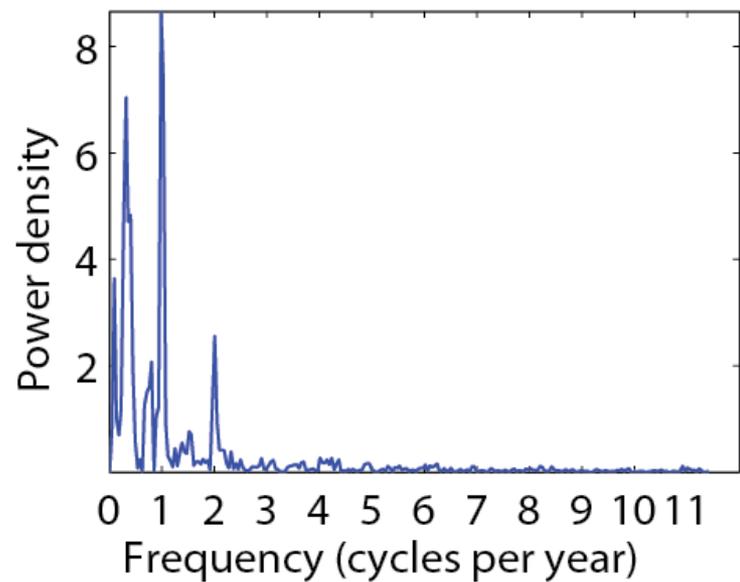
EC 2 0.031



EC 3 0.005

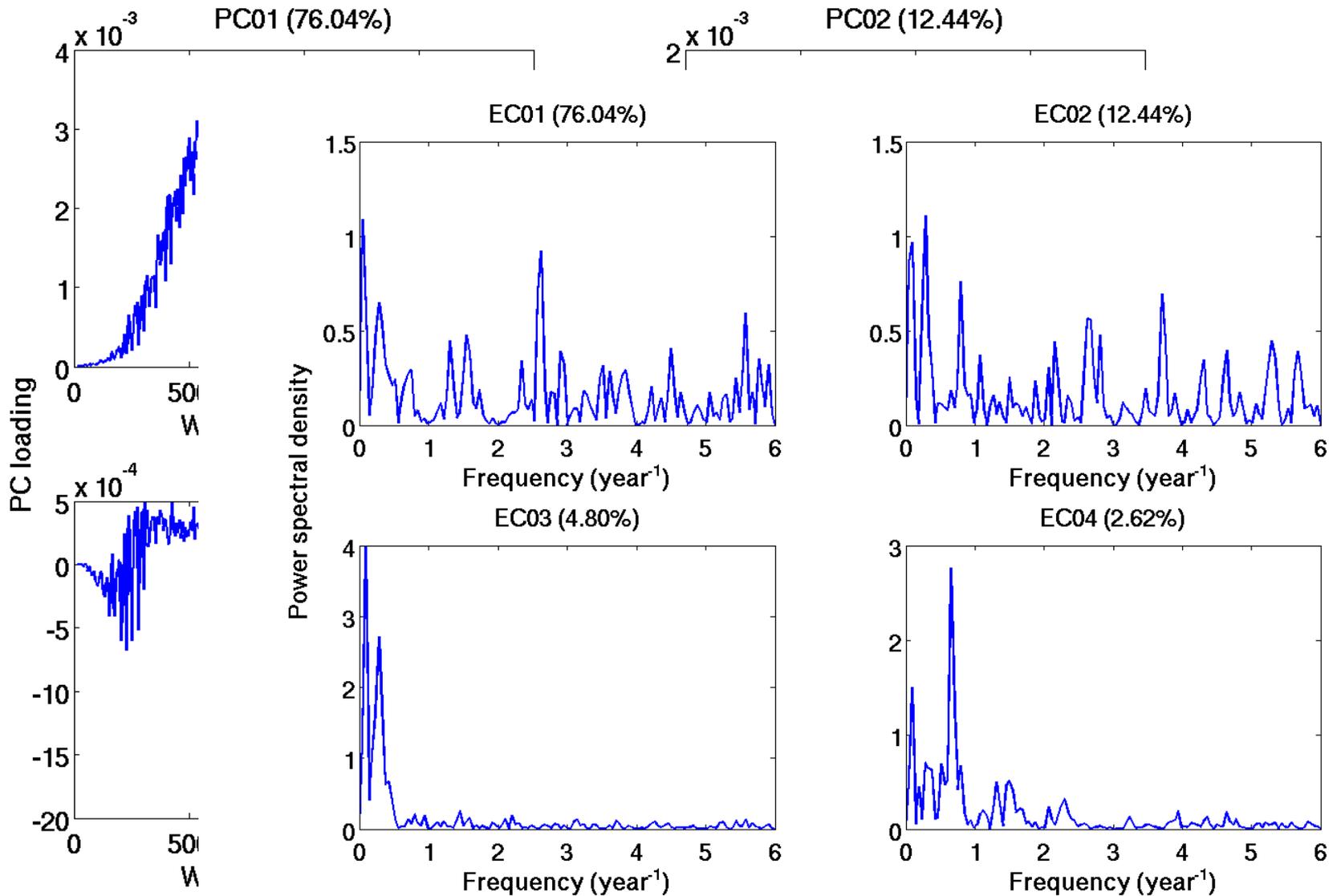


EC 4 0.004



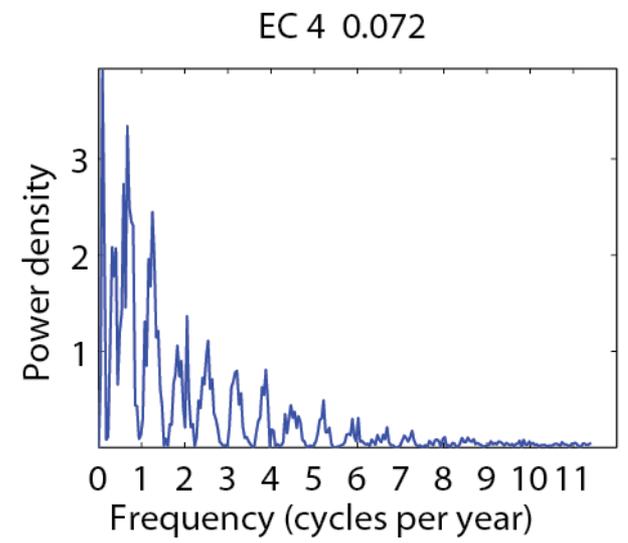
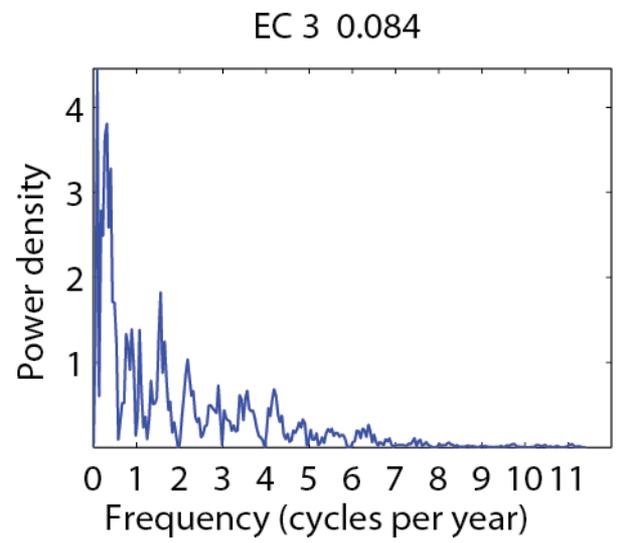
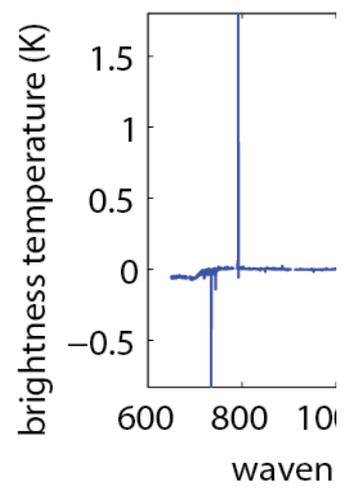
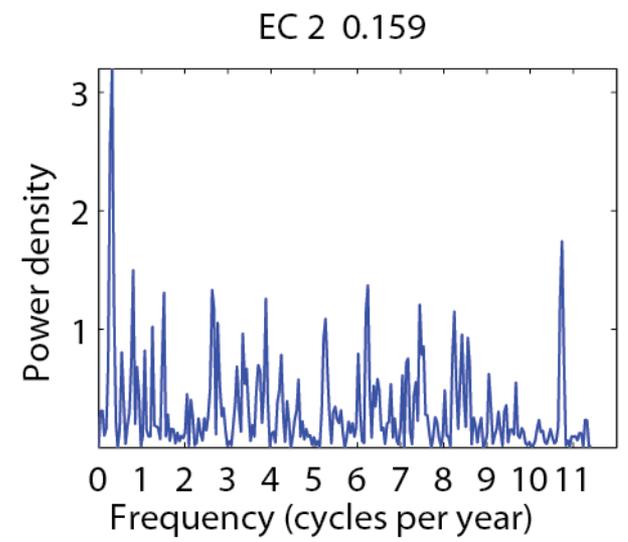
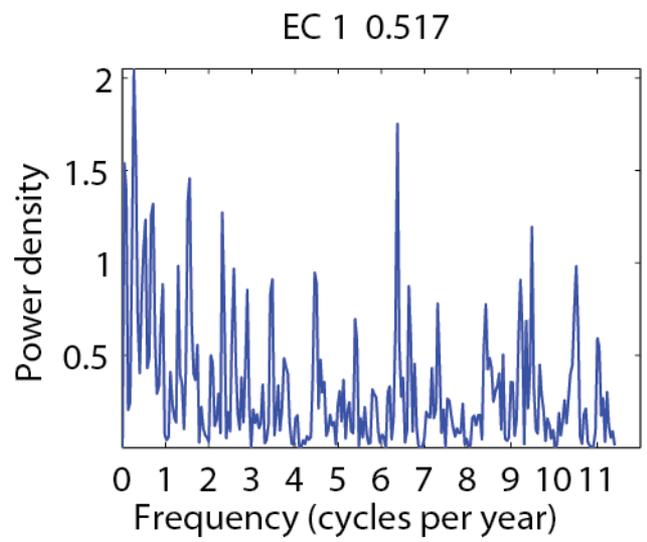
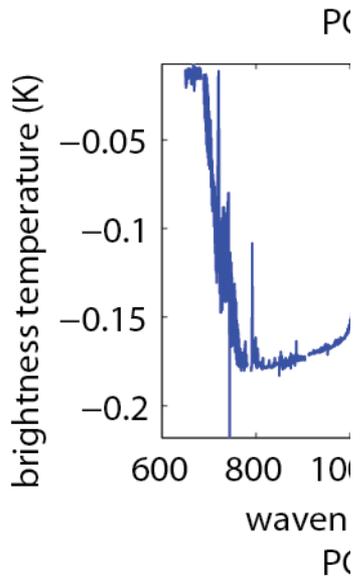


Results after de-seasonalization





Results after de-seasonalization



	NH	NH	SH	SH
PC1	96%	59%	87%	57%
PC2	2.7%	15%	7.4%	18%
PC3	0.6%	10%	4.0%	12%
PC4	0.2%	4.0%	0.4%	3.3%

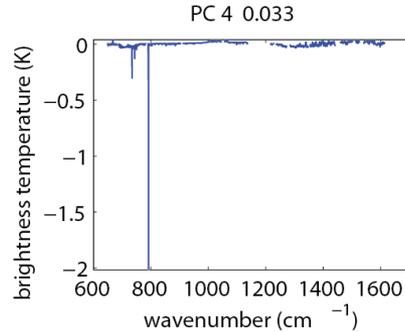
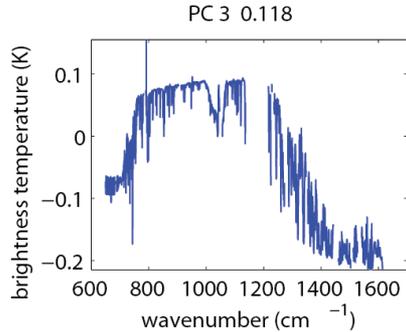
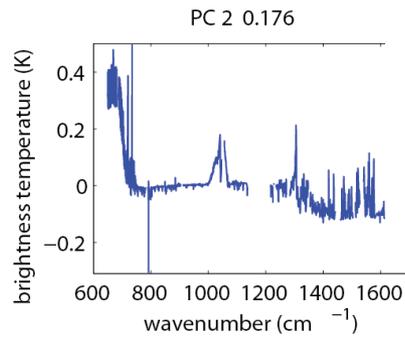
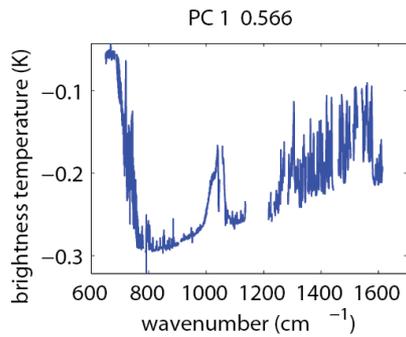
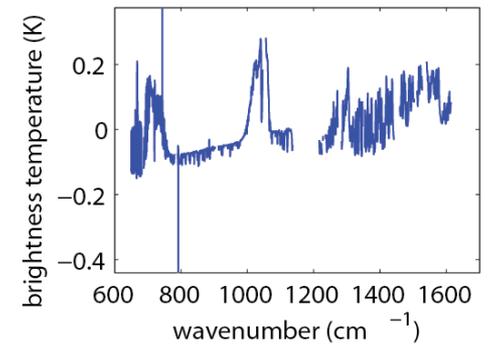
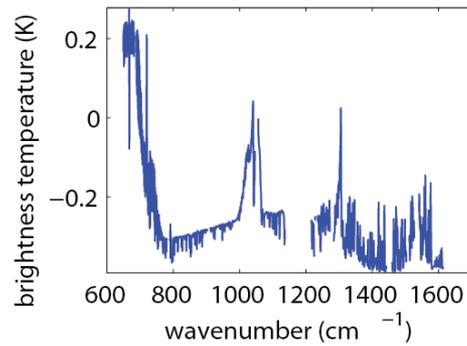
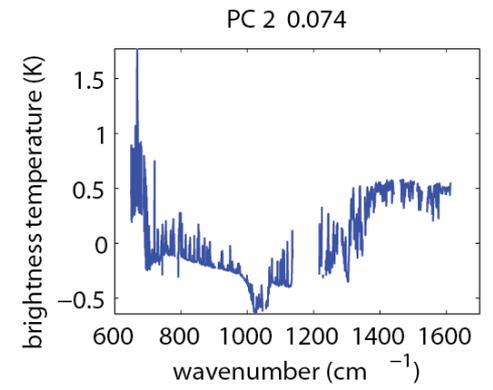
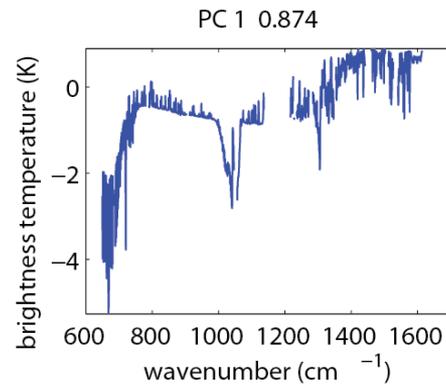
	NH	NH	SH	SH
PC1	A.		A.	
PC2	A.		A.	
PC3	Semi A.		Semi. A.	
PC4	A. & semi a.		Semi. A.	

	NH	NH	SH	SH
PC1	Thermal Contra.	Thermal Contra.	Strat. T & Humidity	Thermal Contra.
PC2	Strat. T	Strat. T	Strat. T & Humidity	Strat. T
PC3	Humidity.	Humidity	Strat. T & Thermal Contra.	Humidity and Strat. T
PC4	Mixed	Negligibly flat	Mixed	Negligibly flat



Only detrended

SH mean radiances

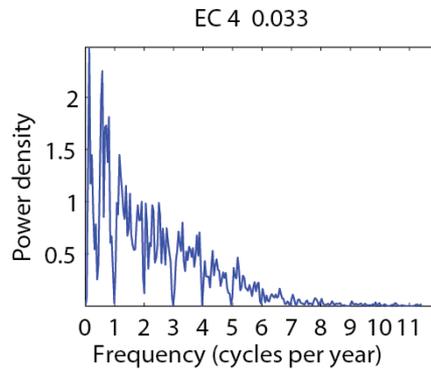
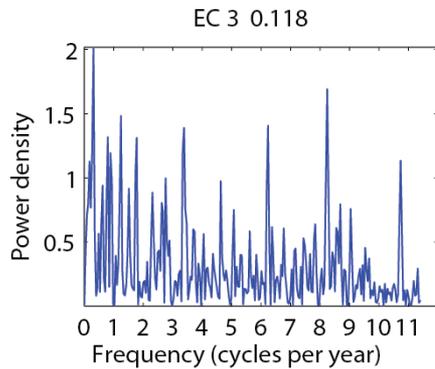
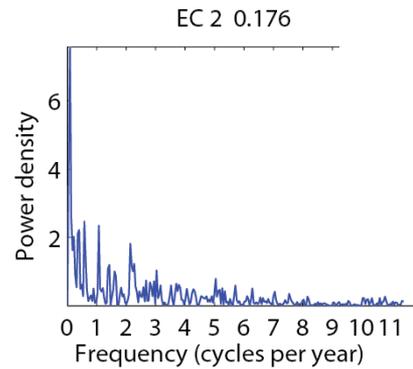
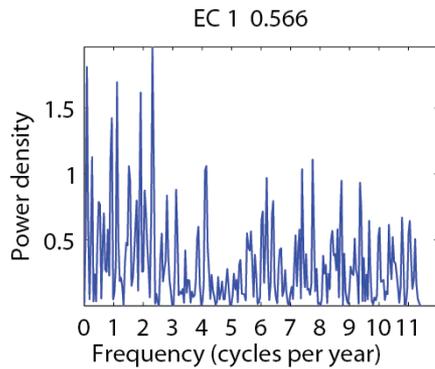
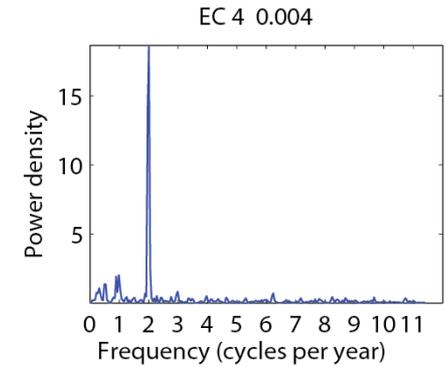
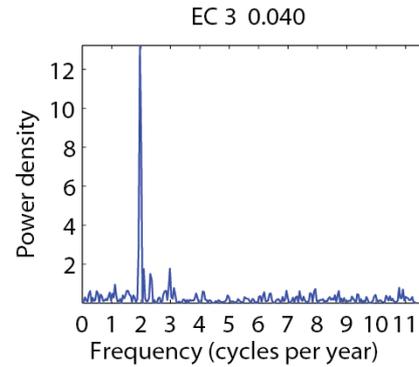
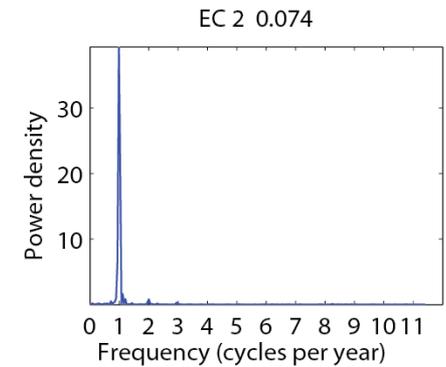
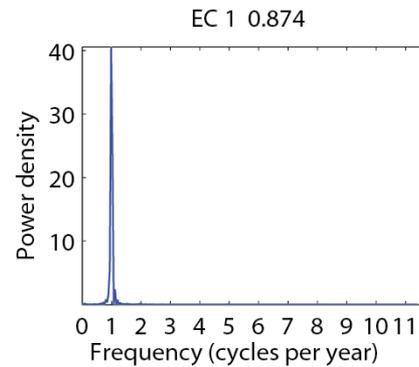


Detrended and deseasonalized



Only detrended

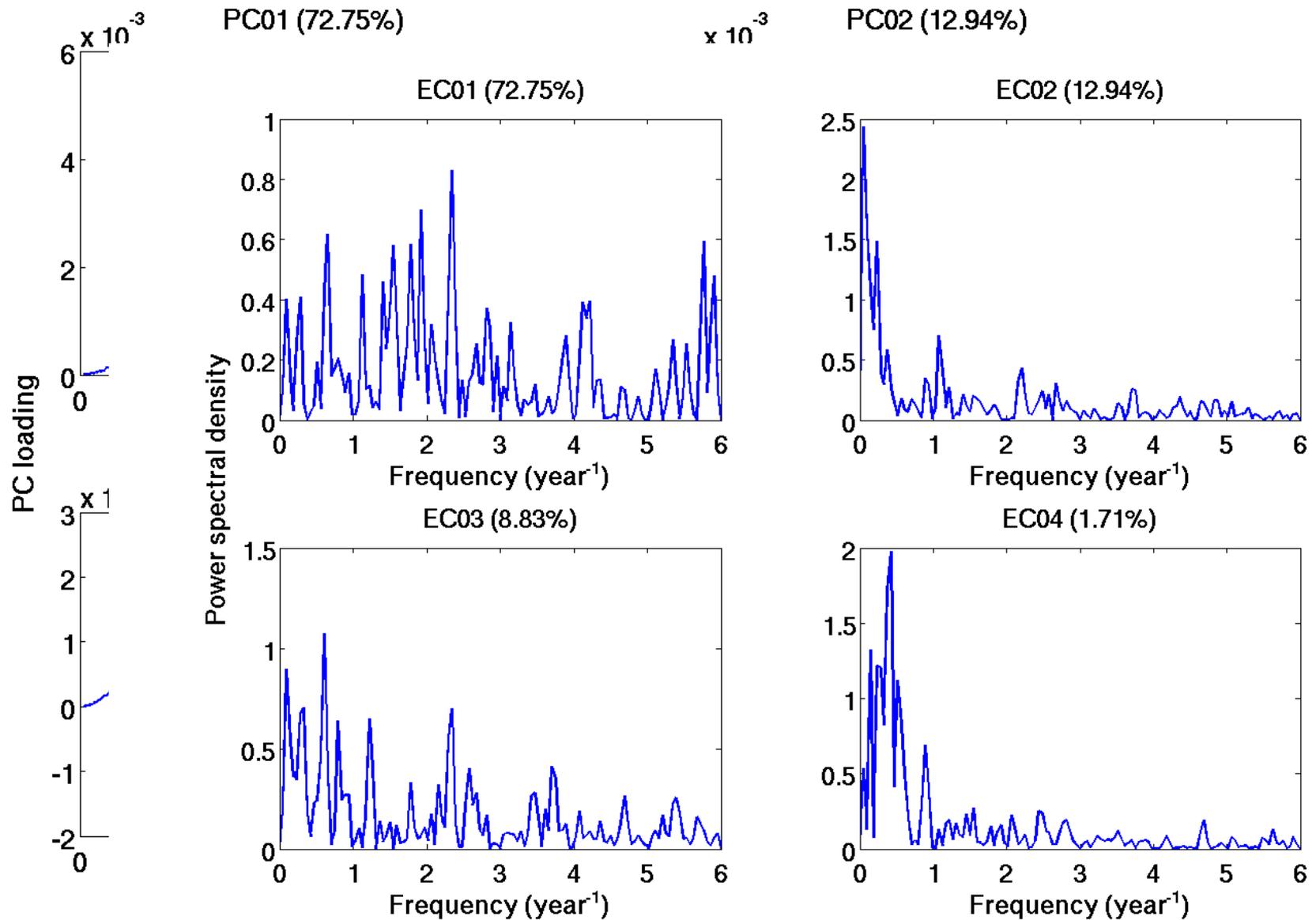
SH mean radiances



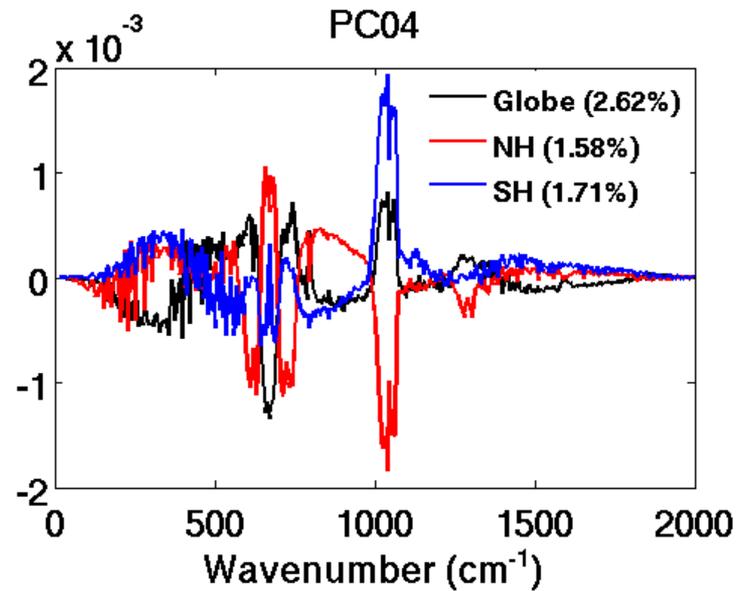
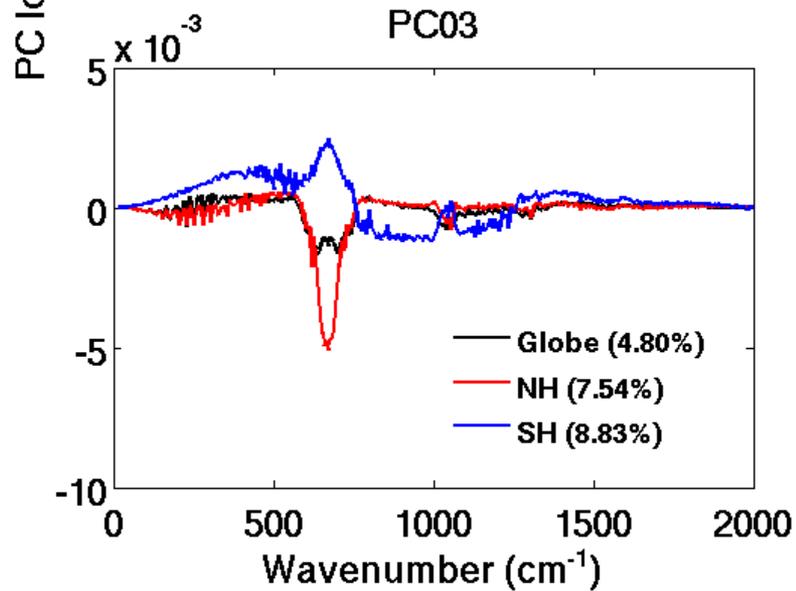
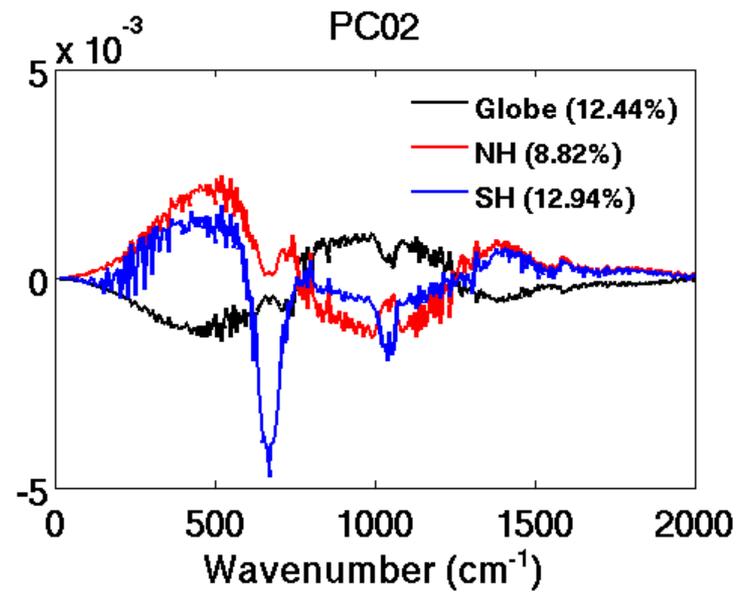
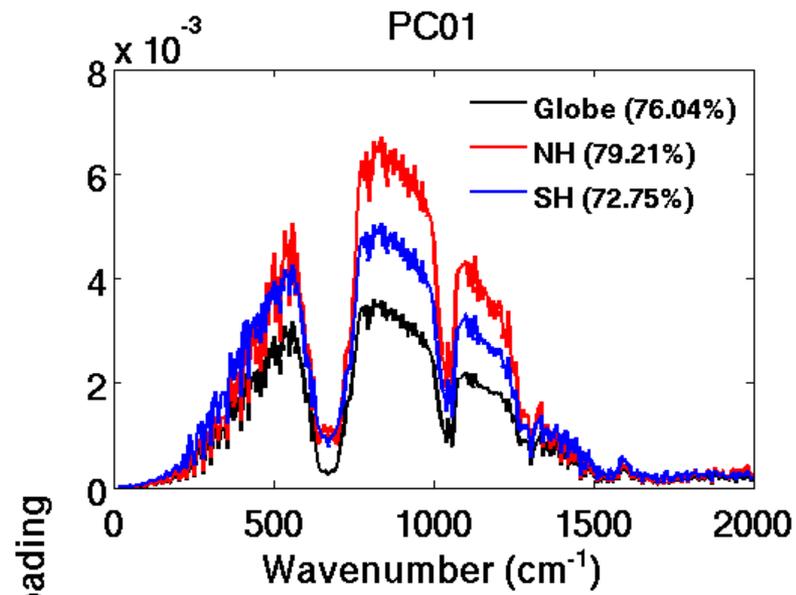
Detrended and deseasonalized



Southern Hemisphere: spectral flux (deseasonalized)

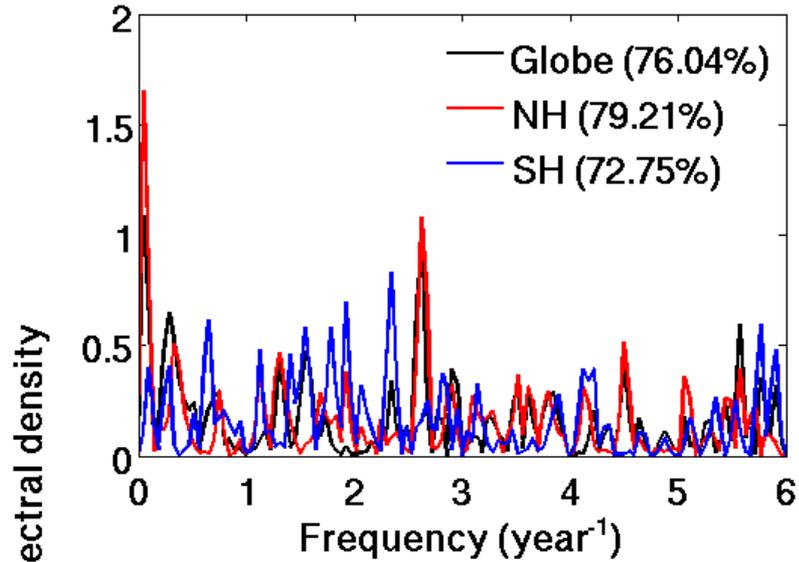


A Comparison of results based on
detrended and deseasonalized
spectra flux over different regions

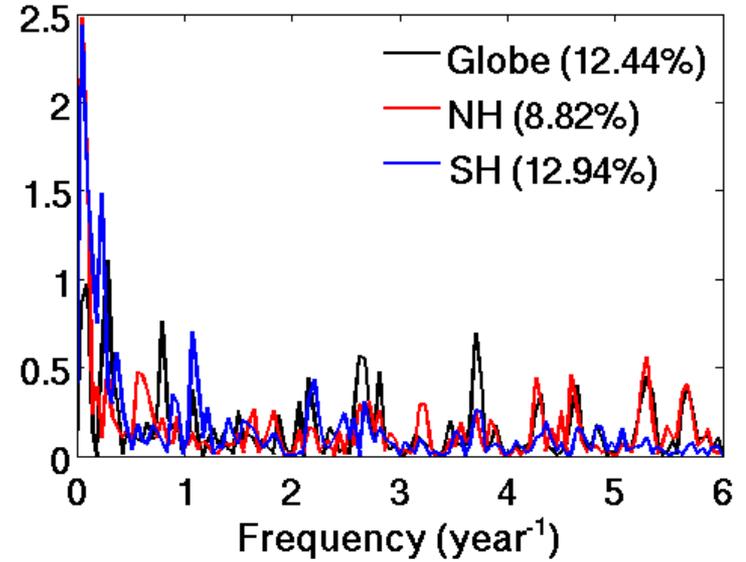




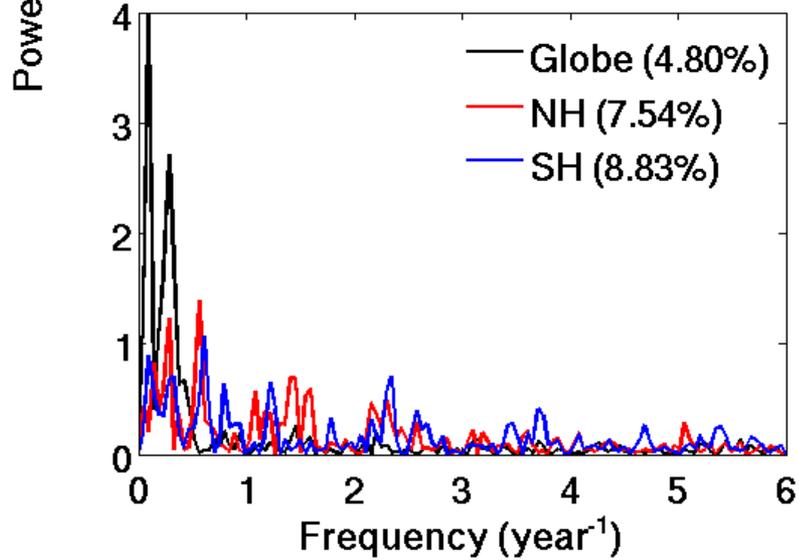
EC01



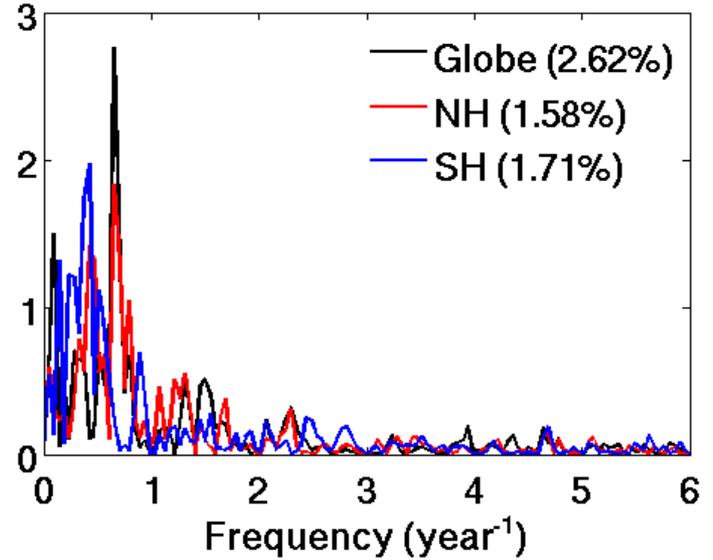
EC02



EC03



EC04





Conclusion

- Depending on which 5 consecutive years are used, standard deviations of annual global-mean spectra can change considerably.
- Seasonal and semi-seasonal cycle dominates the PCs if data is not deseasonalized. Physical causes of the PCs can also change.
 - SH is a good example
- PCA analysis can help identify bad channels of AIRS to some extent
- Near-term work plan
 - Linear inverse modeling of spectral flux and radiances
 - How to “map” spectral variability back to geophysical dimension: spectral radiative kernel approach

Thank You!

Both AIRS radiances and spectral flux data can be provided upon request